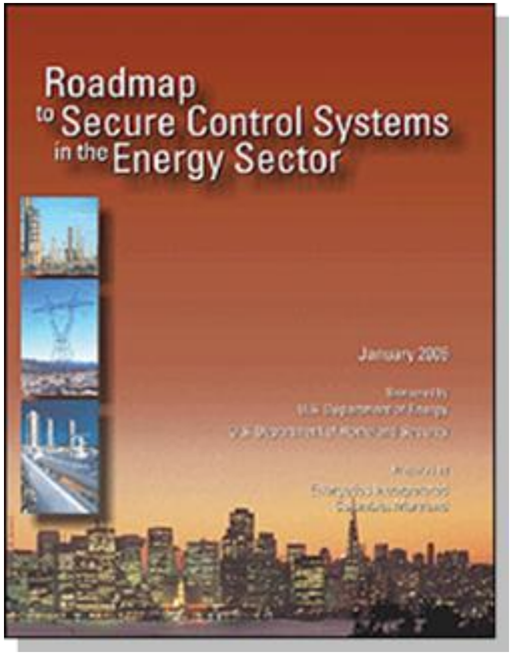
Working to Achieve Cybersecurity in the Energy Sector

"Cybersecurity for Energy Delivery Systems (CEDS)"

Rita Wells
Idaho National Laboratory

Roadmap – Framework for Public-Private Collaboration



- Published in January 2006
- *Energy Sector's* synthesis of critical control system security challenges, R&D needs, and implementation milestones
- Provides strategic framework to
  - align activities to sector needs
  - coordinate public and private programs
  - stimulate investments in control systems security

Roadmap Vision

In 10 years, control systems for critical applications will be designed, installed, operated, and maintained to ***survive*** an intentional cyber assault with no loss of critical function.

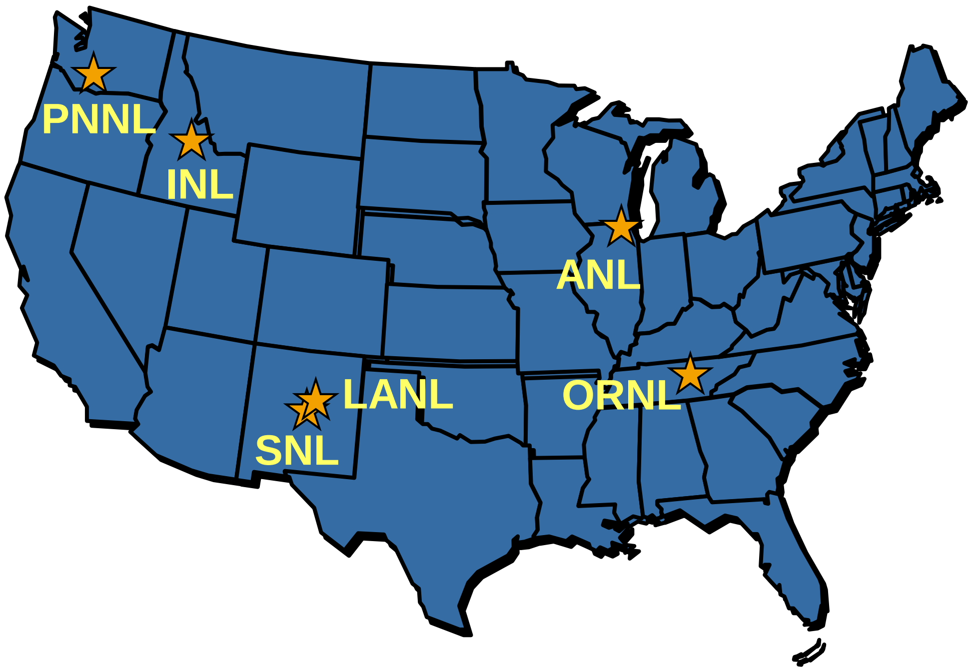
Roadmap – Key Strategies & 2015 Goals

Measure and Assess Security Posture	Develop and Integrate Protective Measures	Detect Intrusion & Implement Response Strategies	Sustain Security Improvements
Energy asset owners are able to perform fully automated security state monitoring and control systems networks with real-time remediation	Next-generation control systems components and architectures produced with built-in, end-to-end security will replace older legacy systems	Control systems networks will inform operator response to provide contingency and remedial actions in response to attempted intrusions	Implement effective incentives through Federal and state governments to accelerate investment in secure control system technologies and practices

DOE National SCADA Test Bed (NSTB) Program

DOE multi-laboratory program *…established 2003*

Supports industry and government efforts to enhance cyber security of control systems in energy sector



"..the only reliable way to measure security is to examine how it fails"

Bruce Schneier, Beyond Fear

Key Program Elements

- Cyber security assessments and recommended mitigations for energy control systems
- Integrated risk analysis
- Secure next generation control systems technology R&D
- Public-private partnership, outreach, and awareness

17 NSTB Facilities From 6 National Labs

IDAHO Critical Infrastructure Test Range
- SCADA/Control System Test Bed
- Cyber Security Test Bed
- Wireless Test Bed
- Powergrid Test Bed
- Modeling and Simulation Test Bed
- Control Systems Analysis Center

SANDIA Center for SCADA Security
- Distributed Energy Technology Laboratory (DETL)
- Network Laboratory
- Cryptographic Research Facility
- Red Team Facility
- Advanced Information Systems Laboratory

PACIFIC NORTHWEST Electricity Infrastructure Operations Center
- SCADA Laboratory
- National Visualization and Analytics Center
- Critical Infrastructure Protection Analysis Laboratory

OAK RIDGE Cyber Security Program
- Large-Scale Cyber Security and Network Test Bed
- Extreme Measurement Communications Center

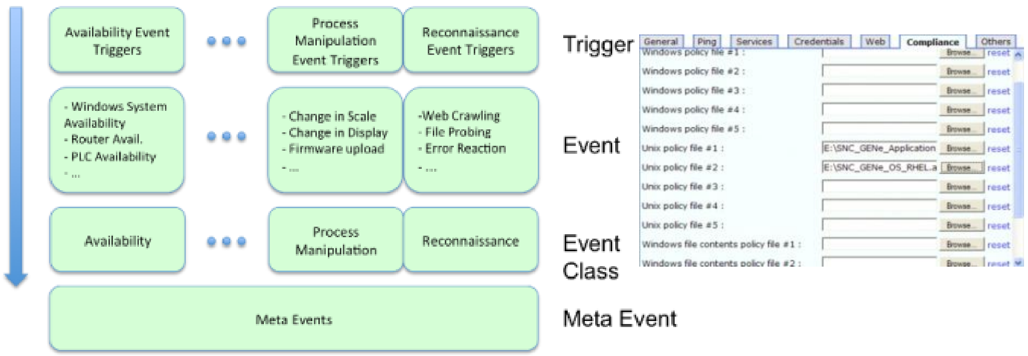
ARGONNE Infrastructure Assurance Center

LOS ALAMOS Cybersecurity Program

2008 First DOE-Awarded Industry Projects

- **Hallmark Project - SEL**
  - **Secure serial communication links**

- **Cyber Security Audit and Attack Detection Toolkit - Digital Bond**
  - **Baseline optimal security configuration**



- **Lemnos Interoperable Security Program - EnerNex**
  - **Interoperable configuration profiles and testing procedures**

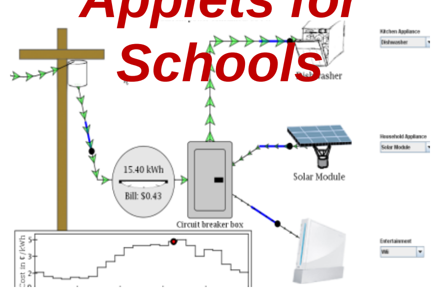
Trustworthy Cyber Infrastructure for the Power Grid

(TCIPG, University-Led Collaboration)

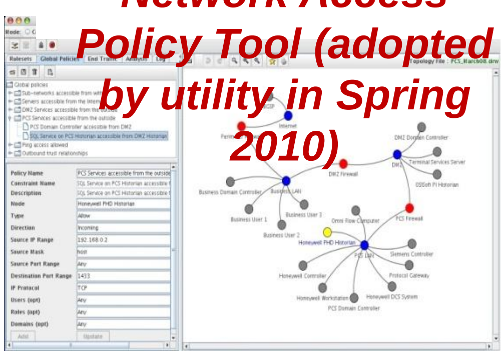
Vision: *Architecture for End-to-End Resilient, Trustworthy & Real-time Power Grid Cyber Infrastructure*

Recent Papers

Applets for Schools



TCIPG NetAPT Network Access Policy Tool (adopted by utility in Spring 2010)



Funding

$18.8 million over 5 years (2009-2014) from DOE and DHS

Facilities

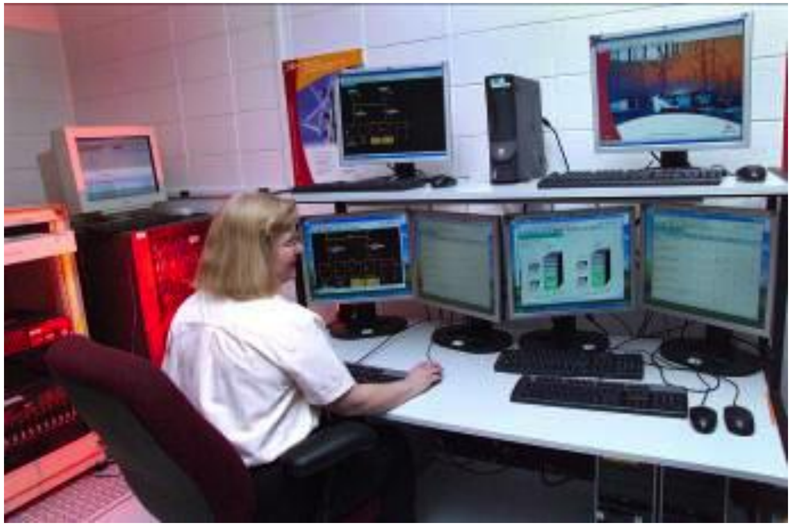
Test bed combining power grid hardware and software with sophisticated simulation and analysis tools

Game-changing R&D Needed to Make *Survivable* Systems a Reality

University of Illinois • Dartmouth College University of California at Davis• Washington State University

DOE National SCADA Test Bed (NSTB)
System Vulnerability Assessments - SCADA/EMS

- **Completed assessments of 38 vendor control systems and associated components on-site at utility field installations and at the INL SCADA Test Bed facility**



Detroit Edison
A DTE Energy Company
AREVA
SIEMENS
TELVENT
GE Energy
TELTONE
ABB
OSI
opening your world
AMERICAN TRANSMISSION COMPANY
OSIsoft.

NSTB Industry Outreach: Vendors, Asset Owners

Objective: Share information with industry related to cyber vulnerabilities and mitigations

Approach: Provide value to industry groups and initiatives who's goal is to improve the cyber security posture of control systems for the Energy Sector

Progress/accomplishments: Provided awareness training for over 4,000 people through Red/Blue Team Advanced training workshops (+180 trained) other training sessions (+400 hands-on), events and conferences

Benefits: Increasing vendor and user awareness related to vulnerabilities and mitigations. Learn from the asset owners the issues and problems associated with mitigating cyber security vulnerabilities. Common Vulnerabilities and lessons cyber exercises shared. Provide awareness for energy sector stakeholders (asset owners, vendors, government, industry organizations, etc.)

2010 Industry-Led DOE-OE DOE CEDS Projects

Telcordia Cybersecurity for Energy Delivery Systems Communications Protocols: Research energy-sector communication protocol vulnerabilities, and develop mitigations that harden these protocols against cyber-attack and that enforce proper communications within energy delivery systems. Lead: Telcordia Technologies Partners: University of Illinois, Electric Power Research Institute (EPRI), DTE Energy

Grid Protection Alliance: Secure Information Exchange Gateway: Research, develop and commercialize a Secure Information Exchange Gateway that provides secure communication of data between control centers. Lead: Grid Protection Alliance Partners: University of Illinois, Pacific Northwest National Laboratory, PJM, AREVA T&D

Sypris Cryptographic Key Management for AMI: Research, develop and commercialize a cryptographic key management capability scaled to secure communications for the millions of smart meters within the Smart Grid Advanced Metering Infrastructure. Lead: Sypris Electronics Partners: Purdue University Center for Education and Research in Information Assurance and Security (CERIAS), Oak Ridge National Laboratory (ORNL), Electric Power Research Institute (EPRI)

SEL Padlock: Research, develop and commercialize a low-power, small-size dongle that provides strong authentication, logging, alarming and secure communications for intelligent field devices operating at the distribution level. Lead: Schweitzer Engineering Laboratories (SEL) Partners: Tennessee Valley Authority (TVA), Sandia National Laboratories (SNL)

2010 Industry-Led DOE-OE DOE CEDS Projects (continued)

SEL WatchDog Managed Switch: Research, develop and commercialize a managed switch for the control system local area network (LAN) that uses whitelist filtering and performs deep packet inspection. Lead: Schweitzer Engineering Laboratories (SEL) Partners: CenterPoint Energy Houston Electric, Pacific Northwest National Laboratories (PNNL)

SEL Whitelist Antivirus: Research, develop and commercialize a whitelist antivirus for control systems solution to be integrated with Schweitzer Engineering Laboratories substation-hardened computers and communication processor. Lead: Schweitzer Engineering Laboratories (SEL) Partners: Dominion Virginia Power (DVP), Sandia National Laboratories (SNL)

Siemens Energy Cyber-Physical System Security Status: Develop and demonstrate a near-real-time cyber and physical security situational awareness capability for the control system environment. Lead: Siemens Energy, Inc. Partners: Sacramento Municipal Utilities District, Pacific Northwest National Laboratories Advisors: CenterPoint Energy, Omaha Public Power District, New York Power Authority

Honeywell RBAC with Least Privilege: Research, develop and commercialize a role-based access control (RBAC) –driven, least privilege architecture for control systems. Lead: Honeywell International, Inc. Partners: University of Illinois, Idaho National Laboratory

2010 Laboratory-Led DOE-OE DOE CEDS Projects

High-Level (4th Gen) Language Microcontroller Implementation - Idaho

- Limits direct access to device memory
- Hardens microcontrollers against low-level cyber-attacks (such as buffer overflow)
- Develop standardized security library to implement secure authentication and data encryption down to the hardware level
- **Partners:** Siemens Corporate Research

Control System Situational Awareness Technology Interoperable Tool Suite - Idaho

- Shows all control system network communications taking place (Sophia);
- Collects all wireless mesh network data message routes;
- Reports unexpected behavior (Mesh Mapper);
- Monitors system health;
- Distinguishes between component failure and cybersecurity incidents (Intelligent Cyber Sensor);
- Performs data fusion for situational awareness (Data Fusion System);
- Determines global effects of local firewall rules (NetAPT)

- **Partners:** Idaho Falls Power, Austin Energy, Argonne National Laboratory, University of Illinois, Oak Ridge National Laboratory, University of Idaho

2010 Laboratory-Led DOE-OE DOE CEDS Projects (continued)

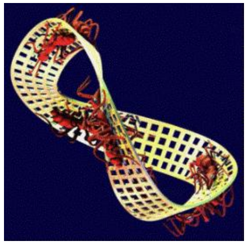
Automated Vulnerability Detection For Compiled Smart Grid Software – Oak Ridge

- Performs static analysis of compiled software and device firmware
  - **Partners:** Software Engineering Institute (SEI), The University of Southern Florida (USF), EnerNex Corporation

Next Generation Secure, Scalable Communication Network for the Smart Grid – Oak Ridge

- Uses adaptive hybrid spread-spectrum modulation format
- Provides superior resistance to multipath, noise, interference and jamming
- Appropriate for high quality-of-service (QoS) applications.
- **Partners:** Pacific Northwest National Laboratory (PNNL), Virginia Tech, OPUS Consulting, Kenexis Consulting

Bio-Inspired Technologies for Enhancing Cybersecurity in the Energy Sector – Pacific Northwest



- Across multiple organizational boundaries found in Smart Grid architectures
- Uses *Digital Ants* - many lightweight and mobile agents whose activities
  - Correlates to produce emergent behavior
  - Draws attention to anomalous conditions--potentially indicative of a cyber-incident
  - **Partners:** Wake Forest University, University of California-Davis, Argonne National Laboratory (ANL), SRI International

For more information …

ie Roadmap
interactive energy Roadmap to secure control systems

Contact:

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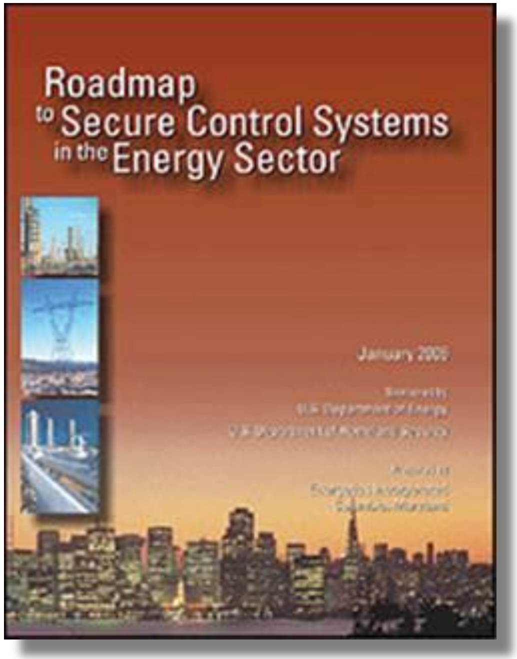


Visit:

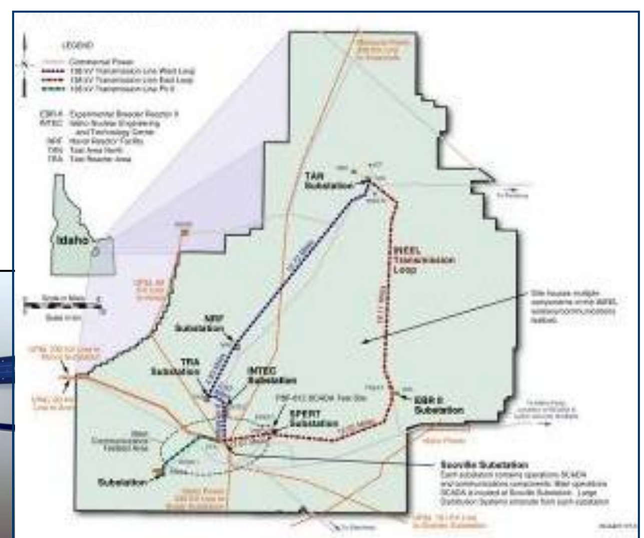
www.oe.energy.gov/controlsecurity.htm

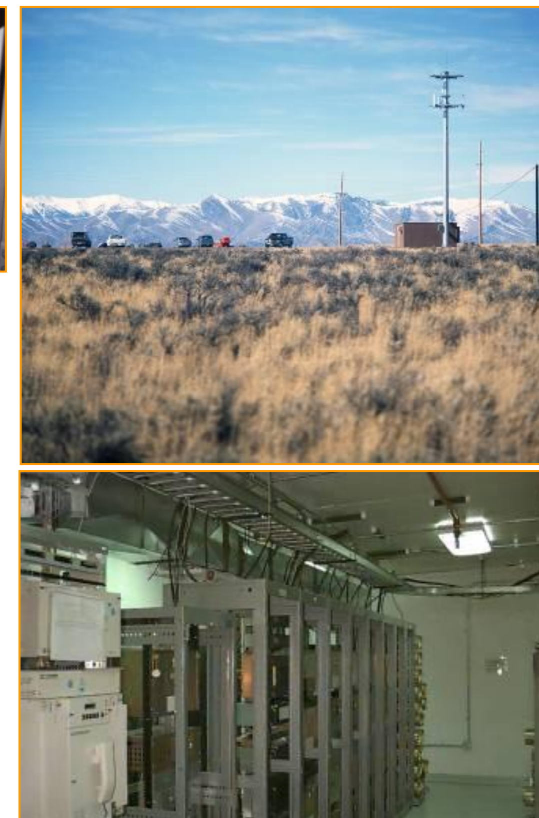
www.controlsystemsroadmap.net

Critical Infrastructure Test Range Complex
Power Grid and Communications - Idaho

- **Secure power distribution system**
  - **61 mi dual 138 kV power loop**
  - **7 substations with 3 commercial feeds**
- **Ability to isolate portions of grid/substation**
- **Centralized SCADA operations center**
- **Power line test area**
- **Real Time Digital Simulator**

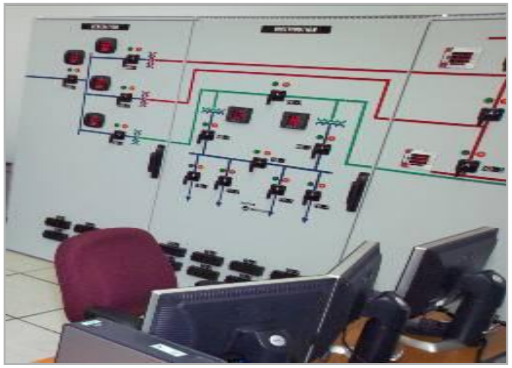
- **Traditional Phone Networks**
- **Ethernet**
- **Next Generation Cellular**
- **Wireless networks**
- **Manage spectrum**





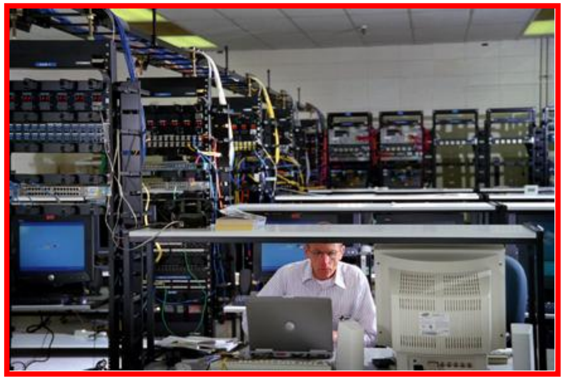
Critical Infrastructure Test Range Complex - Control Systems Idaho

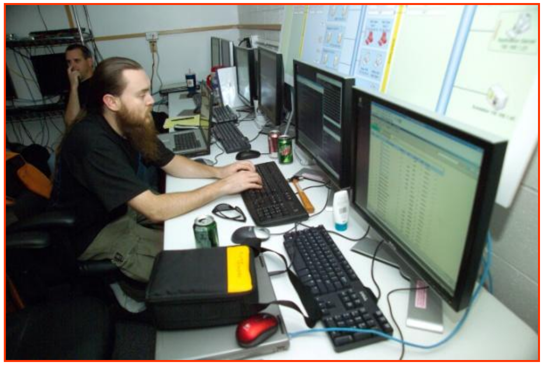
- **Legacy Architectures**
- **Non-production configurations**
- **Latest versions from Vendor Partners**
- **Emulators/simulators**
- **Connectivity to other CITRC assets**



Cyber Security of Control Systems - Idaho

- Cyber Security Assessments on Control Systems
- Zero Day (New) Exploits
- Protocol Analysis
- Partial Code Review and Reverse Engineering
- Component Firmware and Embedded Devices
- Wireless Security
- IDS Review, Testing, Configuration and Design
- Forensics Review and Malware Analysis
- Controlled Information Sharing and Demonstrations
- Security Training / Outreach



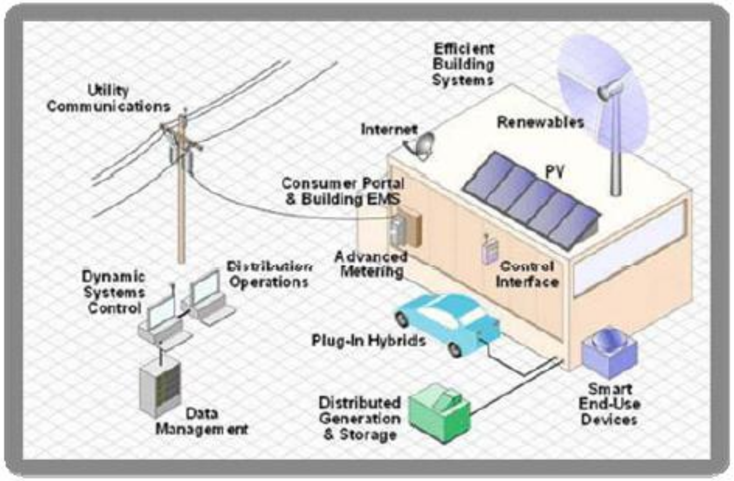


DHS National Cyber Security Division
Control Systems Security Program

www.us-cert.gov/control_systems

Electric Distribution Smart Grid Applications

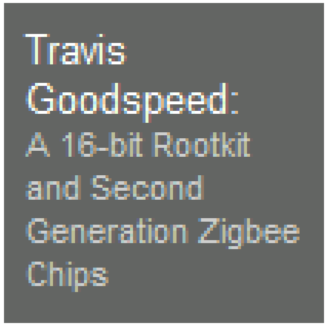
- Two Way Communications Networks for status and control
  - Transmission – better situational awareness
  - Generation – ability to add intermittent renewable generation
  - Distribution –manage distribution load - Billing, Outage Management
- Distribution: Advanced Metering Infrastructure (AMI) will install smart meters on residential, commercial and industrial
  - Remote connect and disconnect
  - Normally wireless to residences
- Physical Access an issue with wireless access points in neighborhoods



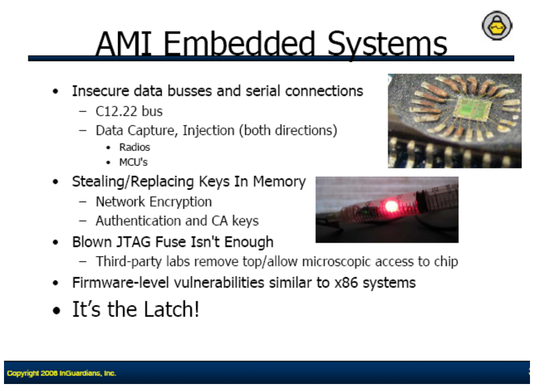
Source: Department of Energy

Vulnerability Discovery, Exploits and Consequences AMI

- Vulnerability Discovery
  – Low barrier of entry to meters and networks for vulnerability discovery and exploitation
- Exploits
  – Being written and already exist prior to smart grid – e.g. wireless
- Consequences
  – Propagating Malware
  – Financial



Vulnerabilities, Exploits and Consequences Observed



Matt Carpenter – InGuardian – Presented at SANS SCADA 2009

Case Study – Fraud

POWER THEFT

If you wish to report any suspicious activity you press the link below to access the online form Theft of Energy .

The Cost of Energy Theft

Each year, the Power Authority lost more than $ 400 million as a result of **theft of** electricity in Puerto Rico. When steals energy cost is transferred to honest customers. Like any other business, the economic losses **of Energy Theft** operational costs increase. These costs alone are high without adding the aggravating circumstance of robbery.

Threat to Security

Energy Theft is a safety hazard.
electrical shock, property dam
involve the thief, but the innoc
Authority.

Informants include the full name on the form can be contacted by ESA to serve as witnesses in the investigation of cases.

Contact the Authority, if you see one of the following situations:

· When a person who is not identified as an employee of the Electric Power Authority, spoke with an accountant or the basis of a counter.

· When a person who is not employed by the Power Authority, working near underground lines or airlines of the ESA.

• If you hear someone comment on how little you pay for electricity from speaking the counter or get a "power saver".

· Use unbridled energy.

Notifies any suspicious activity related to an accountant. Call us at
1-866-664-8783 (1-866-No Hurt), the Customer Service Center 787-521-3434 or visit one of our Customer Service Office.

Complex Networks and Standards Issues

Networks

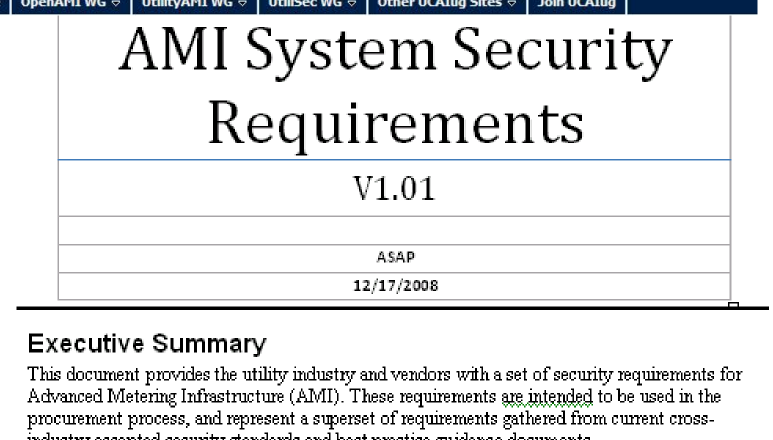
– New networks on networks schemes are complex to defend

– Increased dependence on utility’s wireless communications

– Ownership of data communications and cyber security for power (Base or Municipality vs. Utility)

Standards

– Different security standards NIST; NERC CIP, Zigbee Alliance, IEC, IEEE C12.10, DoDI 8500.2



AMI System Security Requirements

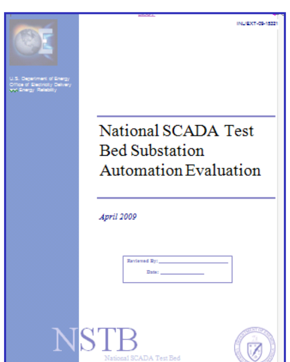
V1.01

ASAP

12/17/2008

Executive Summary

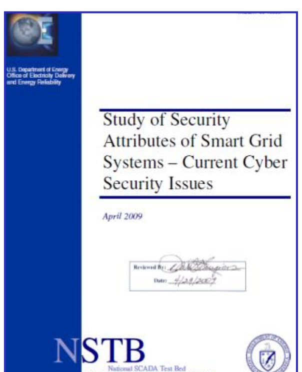
This document provides the utility industry and vendors with a set of security requirements for Advanced Metering Infrastructure (AMI). These requirements are intended to be used in the procurement process, and represent a superset of requirements gathered from current cross-industry accepted security standards and best practice guidance documents.



National SCADA Test Bed Substation Automation Evaluation

April 2009

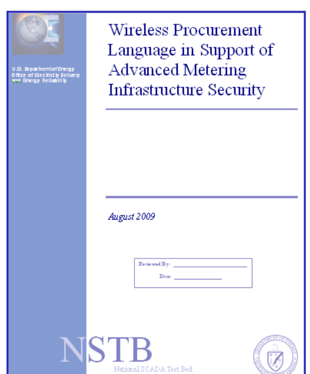
NSTB



Study of Security Attributes of Smart Grid Systems – Current Cyber Security Issues

April 2009

NSTB



Wireless Procurement Language in Support of Advanced Metering Infrastructure Security

August 2009

NSTB

Security Check and Balance Considerations

- Know the Business
  - Coupled or de-coupled rate structures
- Know the Customer Profile
  - Support green energy, price conscience, aware of energy efficiency, hostile or disinterested
- Quality Assurance Checks on Meter Reads
  - At installation, after upgrades, and spot checked periodically
- Revenue Protection Applications
  - Query to meter data management databases for out of bounds
    - Vacation homes, local and private generation
  - Power accounting from distribution substation to neighborhood load – accuracy of substation meters

Recommendations: Incorporating Security

- Start at the beginning of the life cycle
- Proactively require vendors, technology providers and integrators for security assurances and features
- Design in checks and balances
- Third party validation of security measures
- Continuous verification of security measures

Thank You

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